ATC AUTOMATION CONCEPTS

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RESEARCH PROGRAM IN ATC AUTOMATION

OBJECTIVE:

DESIGN OF HUMAN -CENTERED AUTOMATION TOOLS FOR TERMINAL AREA AIR TRAFFIC CONTROL

SCOPE:

- **AUTOMATION CONCEPTS**

- **TRAJECTORY PREDICTION AND CONTROL ALGORITHMS**

- **SCHEDULING AND SEQUENCING ALGORITHMS**

- **HUMAN-SYSTEM INTERFACE DESIGN**

- **TEST AND EVALUATION OF CANDIDATE CONCEPTS**

- **TECHNOLOGY TRANSFER**

PAYOFFS AND PRODUCTS

PAYOFFS

- INCREASED FUEL EFFICIENCY

- REDUCED DELAYS

- EFFECTIVE RESPONSE TO CONTINGENCIES

- IMPROVED WORK ENVIRONMENT FOR CONTROLLERS

PRODUCTS

- CONCEPTS AND DESIGN METHODS FOR AUTOMATED ATC SYSTEMS

- AUTOMATION SOFTWARE

- CONTROLLER SYSTEM INTERFACE AND CONTROLLER PROCEDURES

- TESTS AND EVALUATIONS OF KEY CONCEPTS AT OPERATIONAL SITE

OUTLINE

- **DESIGN PHILOSPHY**

- **AUTOMATION CONCEPT**

- **CONTROLLER SYSTEM INTERFACES**

- **TESTS & EVALUATIONS**

BROAD GUIDELINES

- CONTROLLER RESPONSIBILITIES UNCHANGED

- AUTOMATION TOOLS ASSIST BUT DO NOT
  REPLACE CONTROLLER FUNCTIONS

- PROVIDE ADVISORIES FOR BOTH NORMAL AS
  WELL AS ABNORMAL SITUATIONS

- CONTROLLERS DECIDE WHETHER TO USE OR
  IGNORE ADVISORIES

- NO ADDITIONAL SENSORS REQUIRED ON THE GROUND
  OR ONBOARD

- PROVIDE A BASIS FOR DESIGN OF FUTURE
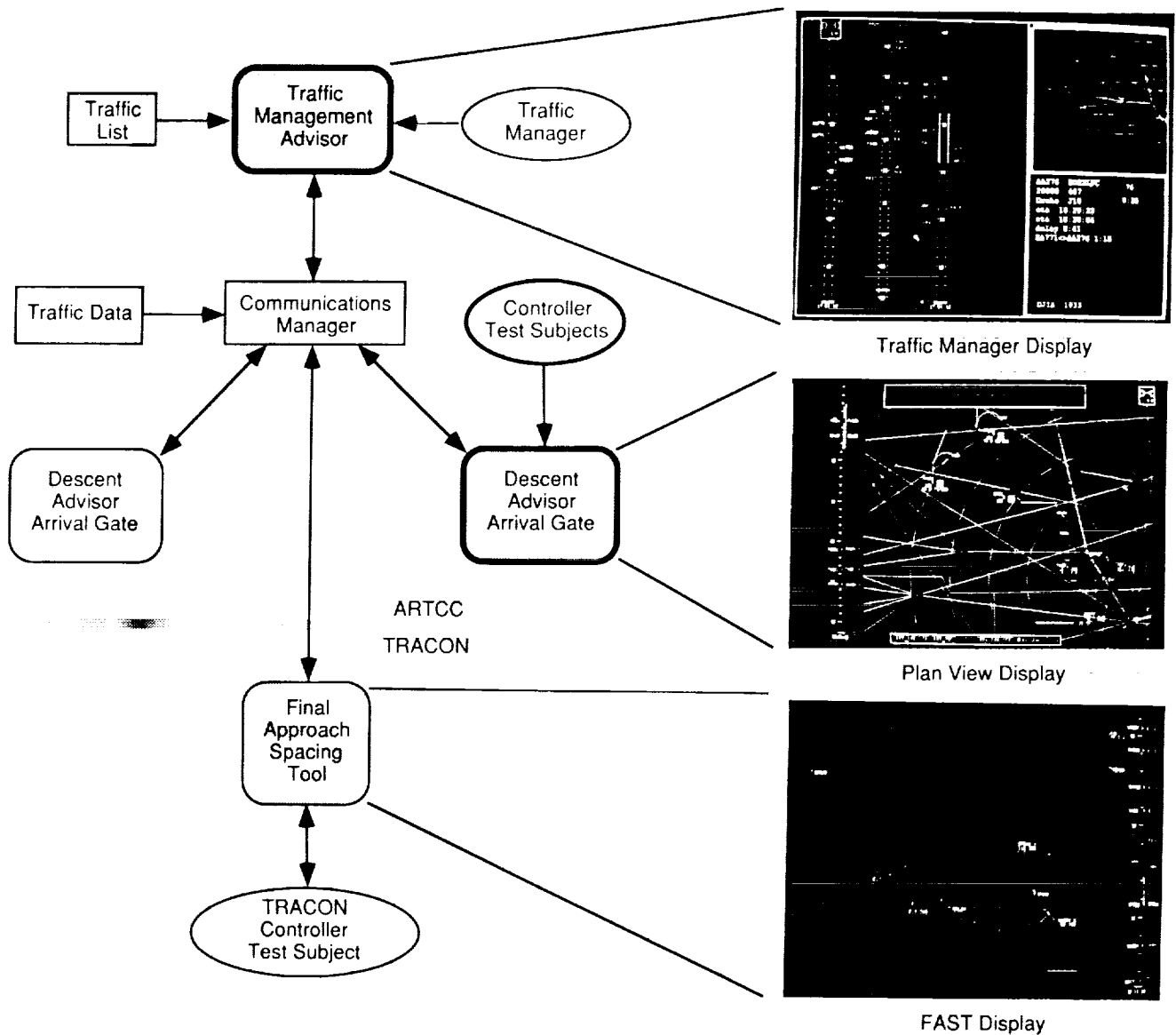 AUTONOMOUS ATC SYSTEMS

OBSERVATIONS AND APPROACH

AIR TRAFFIC CONTROL IS A TEAM PROCESS

- EACH TEAM MEMBER IS AN EXPERT IN HIS POSITION; BUT WORKS CLOSELY WITH OTHER TEAM MEMBERS

- COMMUNICATIONS AND COORDINATION BETWEEN TEAM MEMBERS IS A DOMINANT FEATURE

DESIGN OF AUTOMATION SYSTEM IMITATES STRUCTURE OF MANUAL CONTROL PROCESS

- HIERARCHY OF SUPERVISION AND CONTROL

- EXPERT ADVISORS DESIGNED FOR EACH CONTROLLER POSITION

- COMPLEX COMMUNICATION PROTOCOLS BETWEEN EXPERT ADVISORS

ATC AUTOMATION TOOLS

Traffic List → Traffic Management Advisor ← Traffic Manager

Traffic Data → Communications Manager

Controller Test Subjects

Descent Advisor Arrival Gate

Descent Advisor Arrival Gate

ARTCC
TRACON

Final Approach Spacing Tool

TRACON Controller Test Subject

Traffic Manager Display

Plan View Display

FAST Display

TRAFFIC MANAGEMENT ADVISOR: WHAT IS IT?
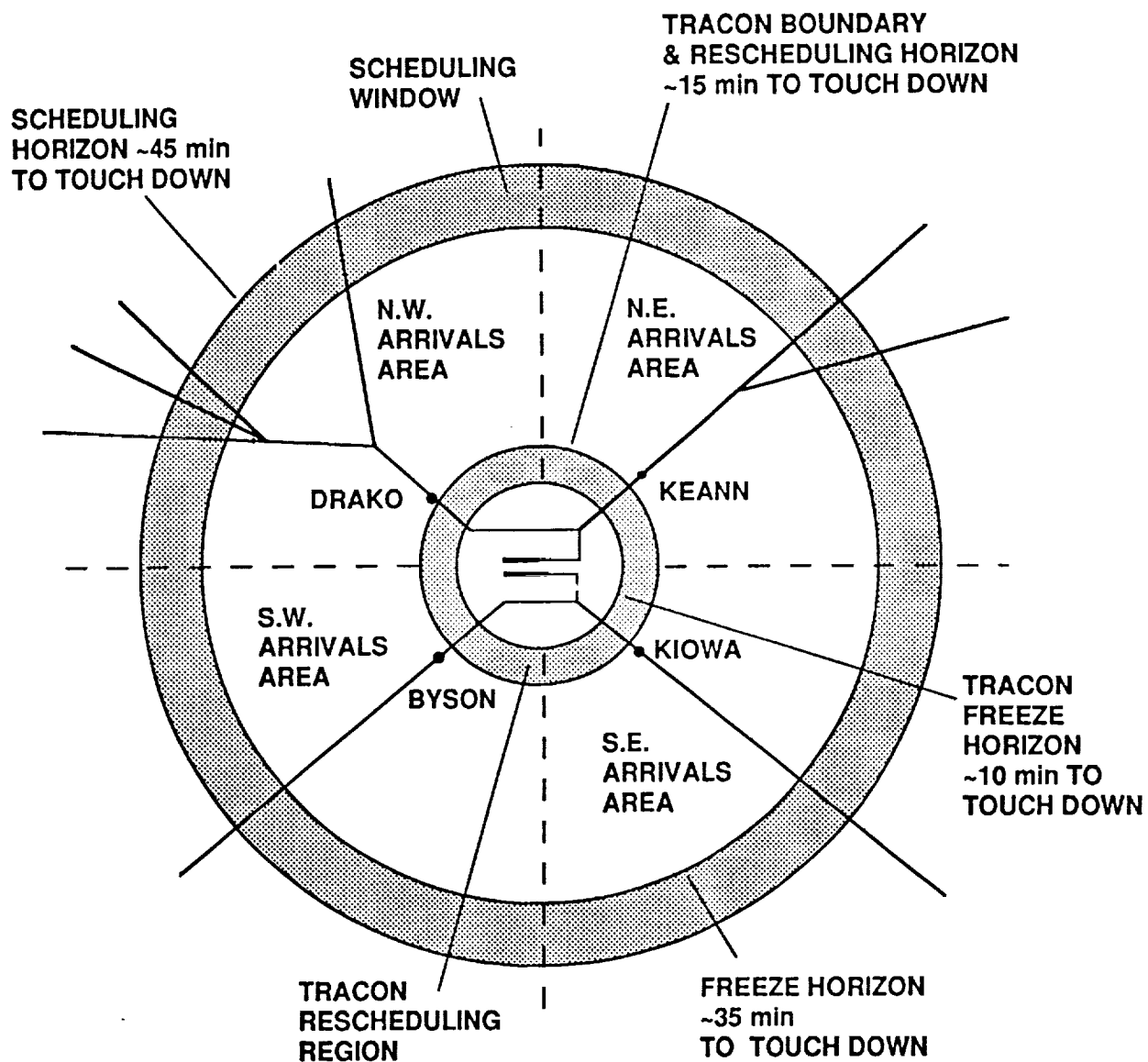
OPTIMUM SCHEDULING ALGORITHMS

- COORDINATE AND MERGE TRAFFIC, CONFLICT FREE

- MINIMIZE AVERAGE DELAY, FCFS, ETC.
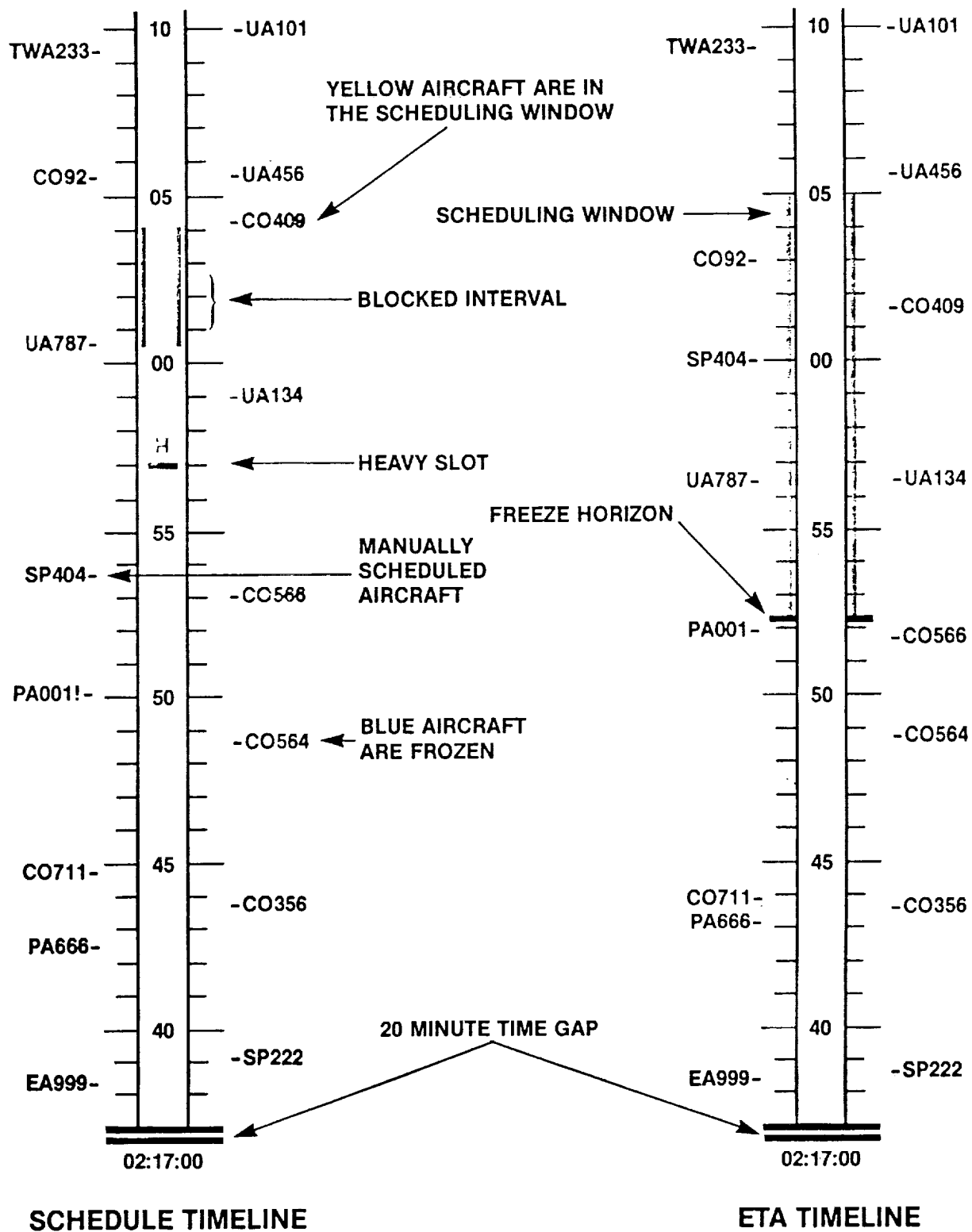
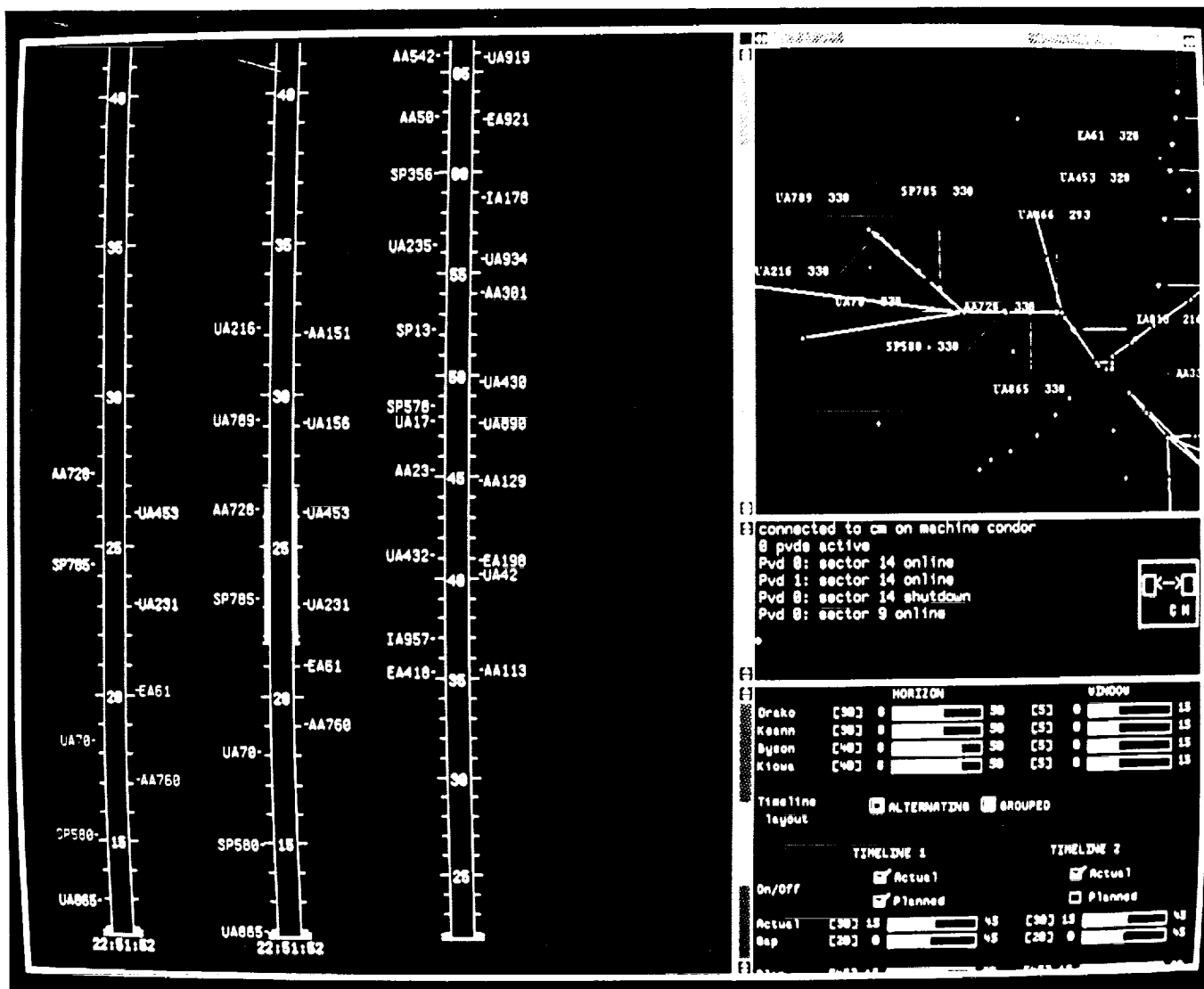- MEET SEPARATION STANDARDS

FLOW CONTROL ALGORITHMS

- CAPACITY MANAGEMENT

- REROUTING: GATE BALANCING, FRONTAL SYSTEM AVOIDANCE, RUNWAY CHANGE

- FLOW MONITORING

INTERACTIVE GRAPHICAL TOOLS FOR MANAGING ALGORITHMS IN REAL TIME

COMMAND AND COMMUNICATIONS INTERFACE FOR DA'S AND FAST

SCHEDULING
HORIZON ~45 min
TO TOUCH DOWN

SCHEDULING
WINDOW

TRACON BOUNDARY
& RESCHEDULING HORIZON
~15 min TO TOUCH DOWN

N.W.
ARRIVALS
AREA

N.E.
ARRIVALS
AREA

DRAKO

KEANN

S.W.
ARRIVALS
AREA

KIOWA

BYSON

S.E.
ARRIVALS
AREA

TRACON
FREEZE
HORIZON
~10 min TO
TOUCH DOWN

TRACON
RESCHEDULING
REGION

FREEZE HORIZON
~35 min
TO TOUCH DOWN

SCHEDULE TIMELINE

ETA TIMELINE

TWA233-
10
-UA101

YELLOW AIRCRAFT ARE IN
THE SCHEDULING WINDOW

CO92-
05
-UA456
-CO409

SCHEDULING WINDOW

BLOCKED INTERVAL

UA787-
00
-UA134

HEAVY SLOT

55

SP404-
MANUALLY
SCHEDULED
AIRCRAFT
-CO566

PA001!-
50

-CO564
BLUE AIRCRAFT
ARE FROZEN

CO711-
45
-CO356

PA666-

40

-SP222

EA999-

20 MINUTE TIME GAP

02:17:00

TWA233-
10
-UA101

CO92-
05
-UA456

-CO409

SP404-
00

UA787-
55
-UA134

FREEZE HORIZON

PA001-
-CO566

50
-CO564

CO711-
PA666-
45
-CO356

EA999-
40
-SP222

02:17:00

Screen photograph of Traffic Management Advisor display.

DESCENT ADVISOR: WHAT IS IT?

A SET OF INTERACTIVE TOOLS FOR ASSISTING CONTROLLERS IN
MANAGING ARRIVAL TRAFFIC EFFICIENTLY UNDER DIVERSE CONDITIONS,
FROM CRUISE TO FINAL APPROACH.

- FUEL OPTIMAL DESCENT ADVISORIES ADAPTED TO AIRCRAFT TYPE,
  AIRLINE PREFERENCE AND WIND PROFILE.

- ACCURATE TIME CONTROL AT FEEDER GATE AND ON FINAL
  APPROACH:

  - TOP OF DESCENT, MACH/IAS, SPEED ADVISORIES

  - ON-ROUTE AND OFF-ROUTE HORIZONTAL GUIDANCE ADVISORIES

- LONG LEAD TIME CONFLICT PREDICTION AND RESOLUTION ALONG
  COMPLEX DESCENT/APPROACH TRAJECTORIES

DESCENT ADVISOR TOOLS

TRAFFIC MANAGEMENT

- DISTANCE SPACING MARKERS AND ADVISORIES
- TIME AT METERING FIX MARKERS AND ADVISORIES
- CONFLICT PREDICTION MARKERS AND ADVISORIES

HORIZONTAL TRAJECTORY MANAGEMENT

- ON-ROUTE ADVISORIES
- DIRECT-TO-WAYPOINT ADVISORIES
- ROUTE INTERCEPT ADVISORIES

SPEED AND ALTITUDE PROFILE MANAGEMENT

- DESCENT SPEED (MACH/IAS PROFILE), RANGE TO TOP OF   DESCENT
- CRUISE SPEED, STANDARD AIRLINE DESCENT PROFILE
- CRUISE + DESCENT

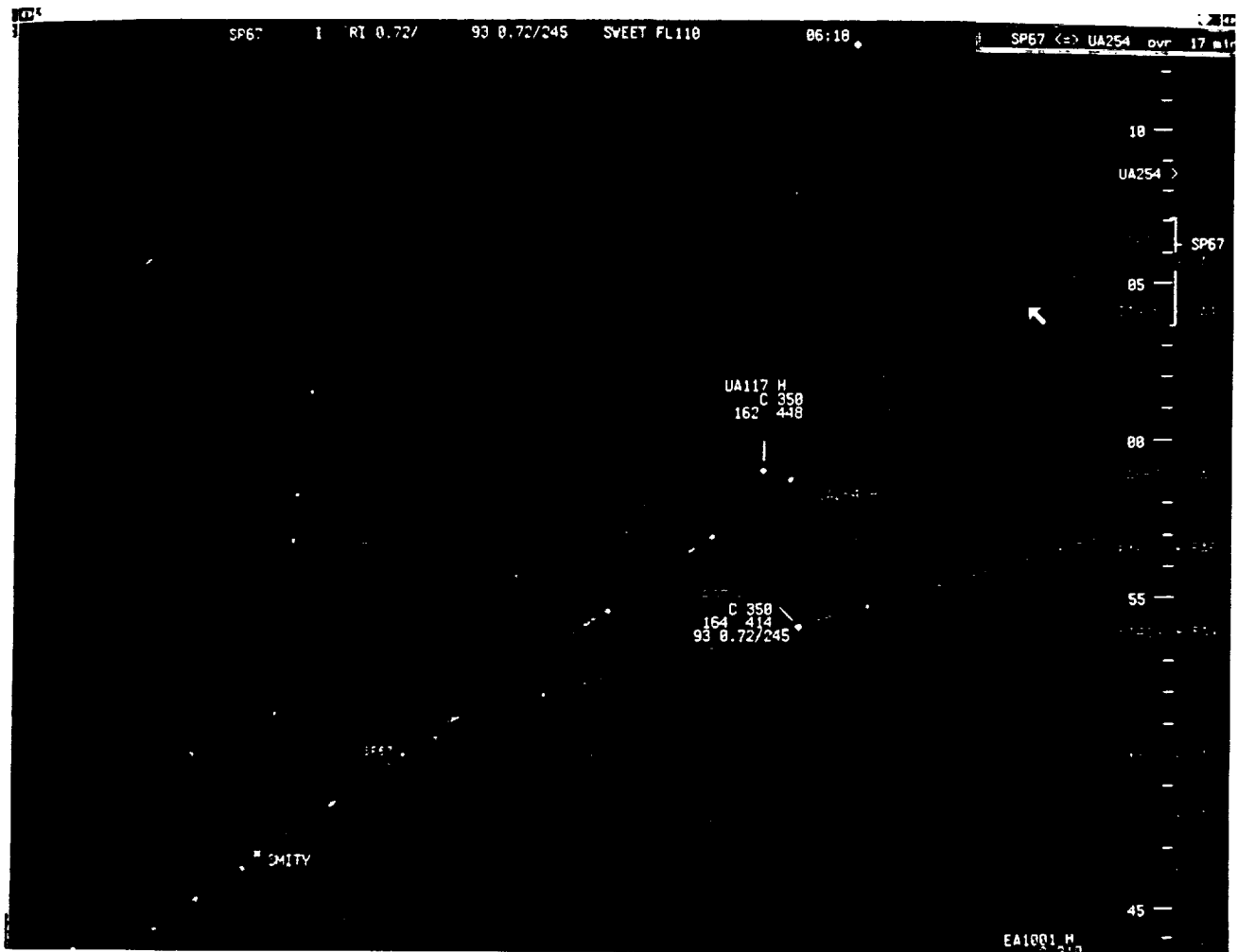### TRAJECTORY TRACKING INFORMATION

- ACCUMULATED TIME ERRORS OF "CLEARED" AIRCRAFT
- BROKEN CLEARANCE INDICATOR
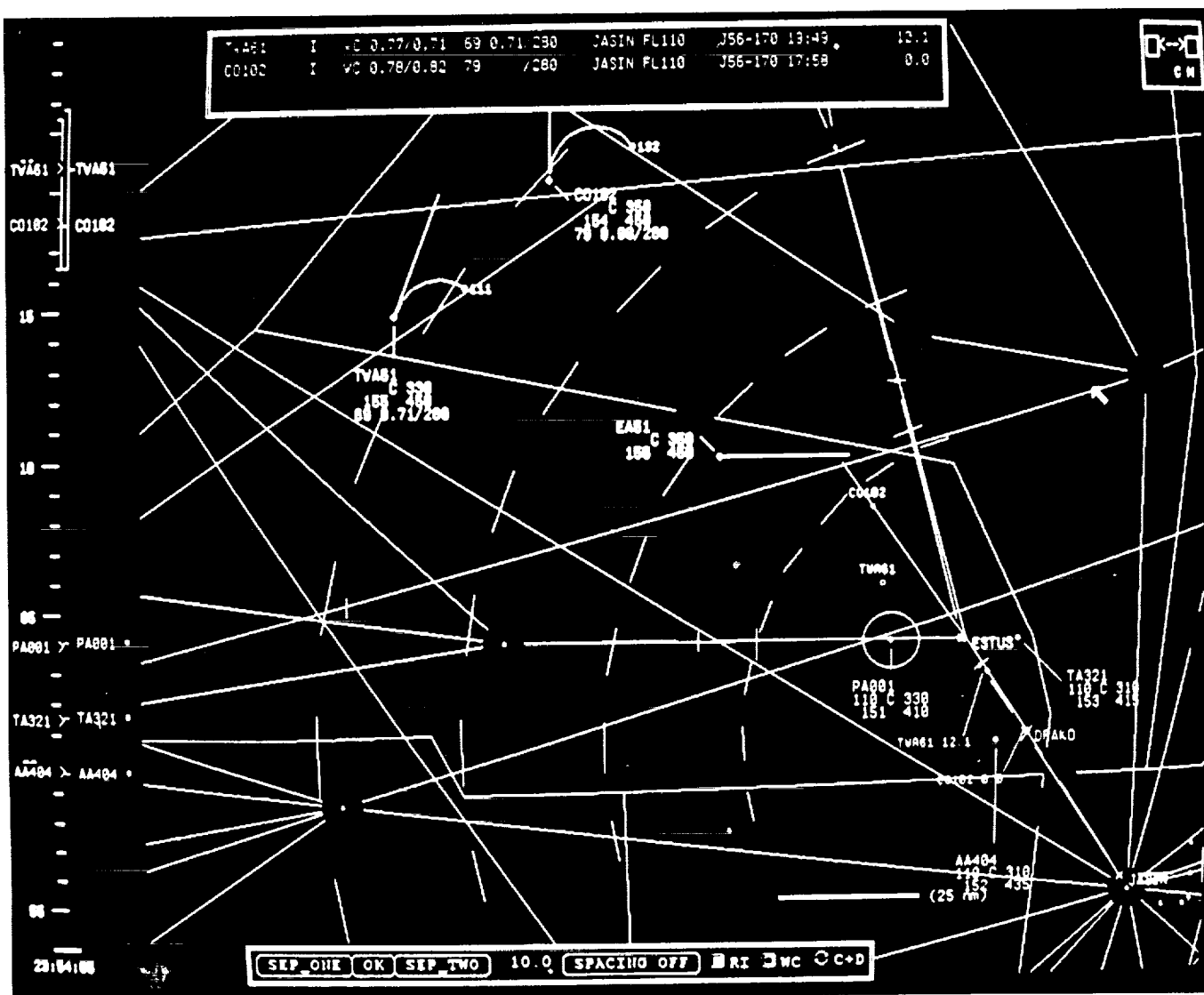
Integrated controller display illustrating waypoint capture guidance to Drako and STAs on the time line.

FINAL APPROACH SPACING TOOL (FAST): WHAT IS IT?

A TOOLBOX OF GRAPHICAL ADVISÓRIES AND CONTROLLER SELECTABLE OPTIONS TO ASSIST TRACON CONTROLLERS IN SEQUENCING AND SPACING ARRIVAL TRAFFIC ON FINAL APPROACH

- ADVISORIES PROVIDED FOR ON-ROUTE AND OFF-ROUTE AIRCRAFT

- DYNAMIC RESCHEDULING AND ADVISORIES FOR ON SCHEDULE AND OFF SCHEDULE AIRCRAFT SUCH AS MISSED APPROACH AND POP-UP

243
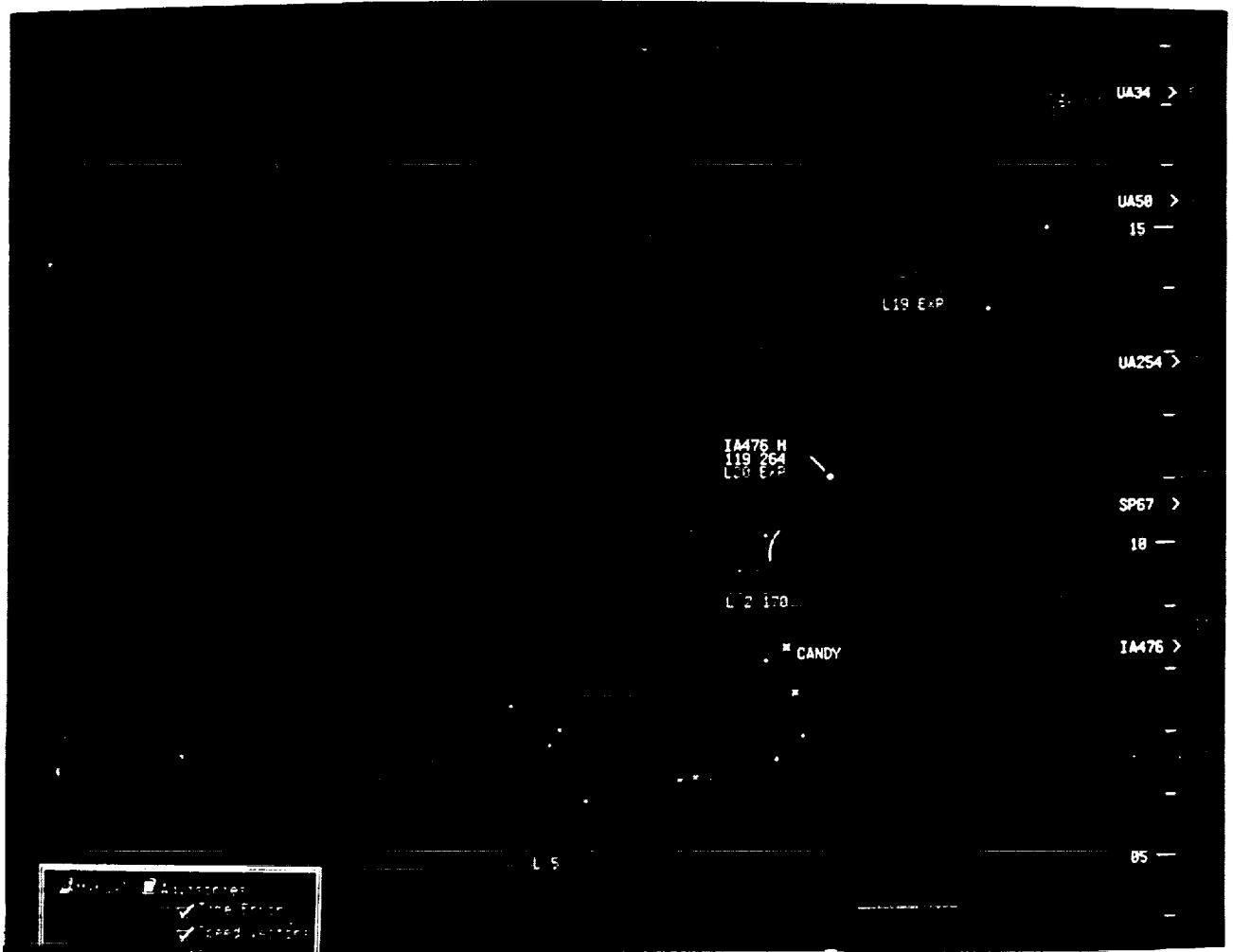
Fast Display

AIR TRAFFIC SIMULATION

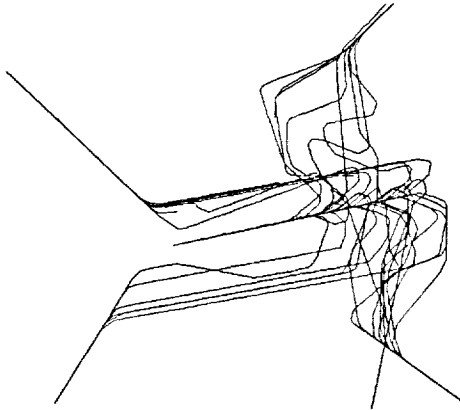Pseudo-Pilot Display

TSRV Simulator
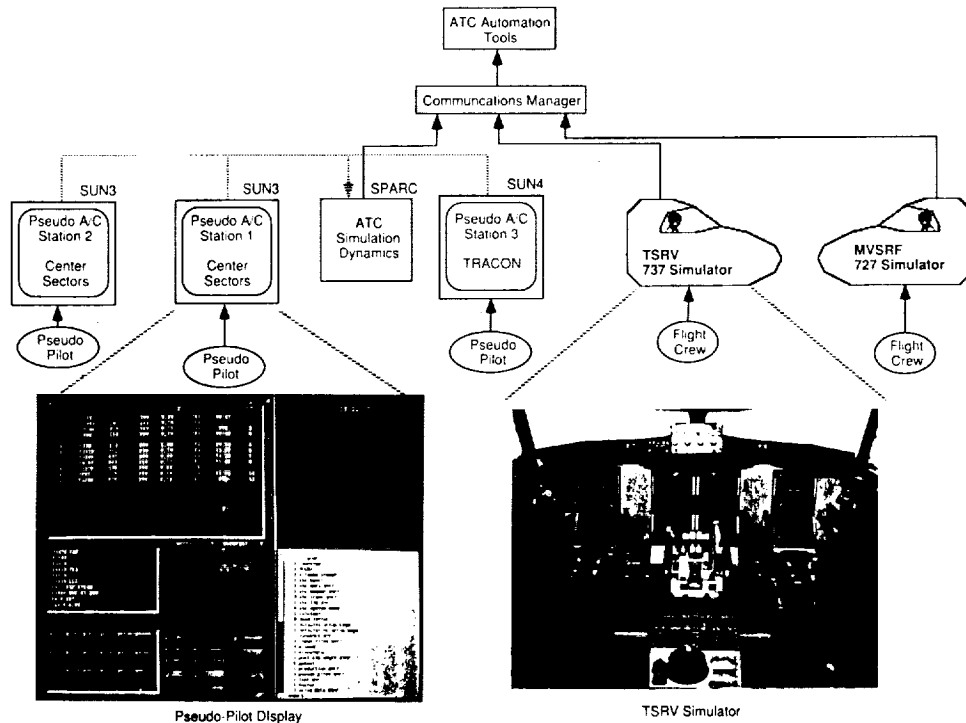
SIMULATION EVALUATIONS

EVALUATION DATE (DURATION)	CONTROLLER SUBJECTS	TEST CHARACTERISTICS
MAY 1988 (3 WEEKS)	9, RETIRED OAKLAND CENTER	INTRAIL SPACING MODE MVSRF-727, LINE PILOTS
MARCH 1989 (3 WEEKS)	2, ACTIVE DENVER CENTER 4, RETIRED OAKLAND CENTER 3, RETIRED BAY TRACON	TIME CONTROL MODE; INTEGRATION OF TRAFFIC MANAGEMENT ADVISOR (TMA), DA, AND FINAL APPROACH SPACING TOOL (FAST); MVSRF-727, LINE PILOTS
JULY 1989 (3 WEEKS)	6, ACTIVE OAKLAND CENTER 2, RETIRED BAY TRACON	TIME CONTROL MODE; INTEGRATION OF 4D EQU. AIRCRAFT; TMA + DA + FAST; TSRV-737, LINE PILOTS
JAN - JUNE 1990?	ACTIVE CENTER AND TRACON CONTROLLERS	SHADOW CONTROL OF LIVE DENVER ARRIVAL TRAFFIC

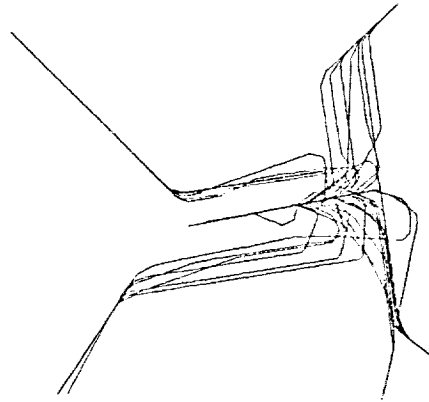## EFFECTIVENESS OF DESCENT ADVISORIES
COMPOSITE TRAJECTORIES FROM ATC SIMULATION OF DENVER AREA

- ALL ARRIVALS INITIALLY SCHEDULED CONFLICT-FREE TO TOUCHDOWN AT TOP OF DESCENT

- TRAFFIC LOAD AT RUNWAY CAPACITY

WITHOUT ADVISORIES   WITH ADVISORIES

CONCLUDING REMARKS

- PRIMARY BASIS FOR AUTOMATION TOOLS IS AN ACCURATE AND VERSATILE TECHNIQUE FOR PREDICTING TRAJECTORIES AT LEAST 30 MINUTES INTO THE FUTURE

- ACCURATE PREDICTION TECHNIQUE IS ESSENTIAL FOR EFFECTIVE PLANNING AND CONTROL

- COMPUTER GENERATED PLANS AND ADVISORIES SHOULD NOT BE INCOMPATIBLE WITH ACCEPTED CONTROLLER TECHNIQUES.

- TOOLS FOR ESSENTIAL CONTROLLER NEEDS TAKE PRECEDENCE OVER TOOLS FOR FLOW OPTIMIZATION.

- AFTER MEETING ESSENTIAL NEEDS, TOOLS SHOULD HELP MINIMIZE DELAYS AND FUEL CONSUMPTION.

- WELL DESIGNED TOOLS OFFER INTELLIGENT ADVISORIES UNDER ABNORMAL AS WELL AS NORMAL SITUATIONS.

CONCLUDING REMARKS
(continued)

- DESIGN OF GRAPHICAL AND OTHER INTERFACES POSES THE MOST DIFFICULT DESIGN CHALLENGE.

- TO BE EFFECTIVE TOOLS MUST BE CUSTOM-DESIGNED FOR EACH TYPE OF CONTROL POSITION.

- ADVISORY TOOLS ARE A NECESSARY TRANSITONAL STEP TOWARD A FUTURE AUTOMATED ATC SYSTEM.